The Consultative Committee for Space Data Systems

Draft Recommendation for
Space Data System Standards

SPACE LINK EXTENSION—RETURN OPERATIONAL CONTROL FIELDS SERVICE SPECIFICATION

DRAFT RECOMMENDED STANDARD

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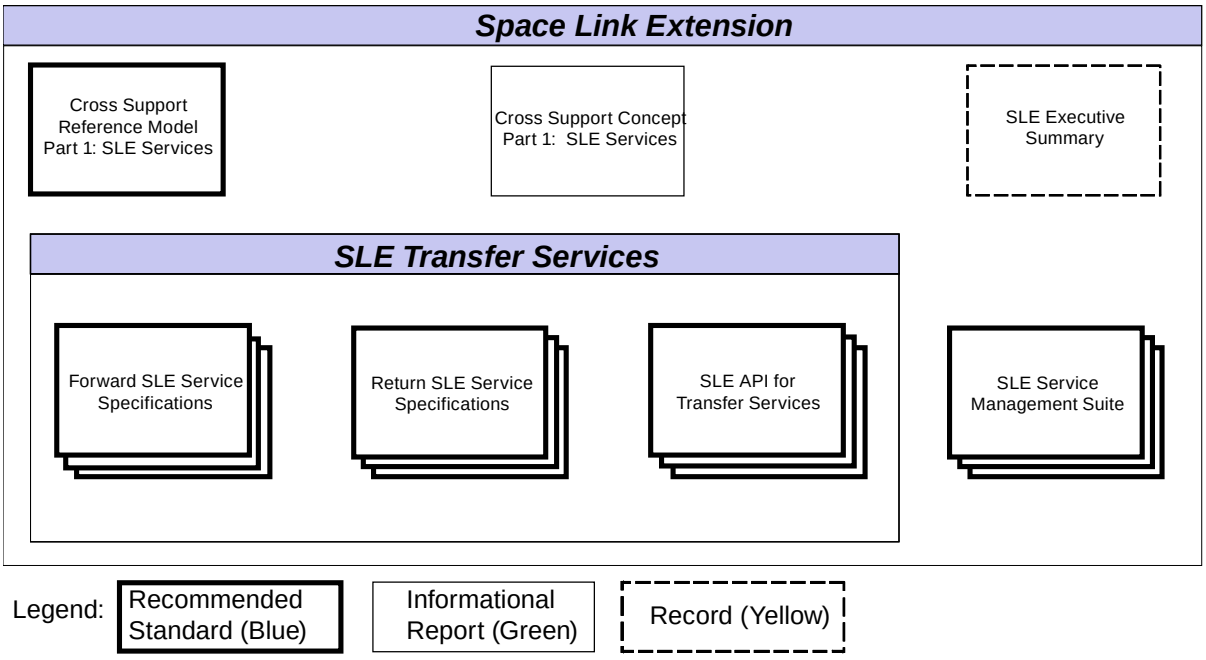

Figure 1-1: SLE Services Documentation

a) *Cross Support Concept—Part 1: Space Link Extension Services* (reference [E2]): a Report introducing the concepts of cross support and the SLE services;

b) *Cross Support Reference Model—Part 1: Space Link Extension Services* (reference [1]): a Recommended Standard that defines the framework and terminology for the specification of SLE services;

c) *SLE Return Service Specifications*: a set of Recommended Standards that will provide specification of all return link SLE services (this Recommended Standard is one of the specifications in that set);

d) *SLE Forward Service Specifications*: a set of Recommended Standards that will provide specification of all forward link SLE services;

e) *SLE API for Transfer Services Specifications*: a set of Recommended Standards that provide specifications of an Application Program Interface and a mapping to TCP/IP as underlying communications service for SLE services;

f) *SLE Service Management Specifications*: a set of Recommended Standards that establish the basis of SLE service management.

g) Mission Data Operation System (MDOS);

h) Mission User Entity (MUE);

i) offline delivery mode;

j) online delivery mode;

k) operation;

l) performer;

m) physical channel;

n) return data;

o) Return All Frames channel (RAF channel);

p) Return All Frames service (RAF service);

q) Return Master Channel Operational Control Field service (MCOCF service);

r) Return Virtual Channel Operational Control Field service (VCOCF service);

s) service agreement;

t) service provider (provider);

u) service user (user);

v) SLE Complex;

w) SLE Complex Management;

x) SLE data channel;

y) SLE Functional Group (SLE-FG);

z) SLE Protocol Data Unit (SLE-PDU);

aa) SLE Service Data Unit (SLE-SDU);

bb) SLE service package;

~~cc) SLE System;~~

cc) SLE transfer service instance;

dd) SLE transfer service production;

ee) SLE transfer service provision;

ff) SLE Utilization Management;

gg) space link;

c) the virtual channel identifier (VCID) of the frame matches the VCID of the global VCID specified in the ROCF-START operation;

d) the type of the control word contained in the extracted OCF matches the type specified in the ROCF-START operation;

e) for CLCW reports, i.e., for OCFs containing a control word of type '0' (reference [4]), the telecommand virtual channel that the report refers to matches the telecommand virtual channel specified in the ROCF-START operation.

1.6.1.8.5 Frame Error Control Field

The Frame Error Control Field (FECF) of a frame is the FECF of a TM Transfer Frame (reference [3]) or the FECF of an AOS Transfer Frame (reference [5]), as applicable.

1.6.1.8.6 Initiator

The initiator is the object that issues the request to bind to another object (the responder).

NOTE – In other words, the initiator is always the invoker of the request to bind to another object. Therefore, in the context of the request to bind, the terms 'initiator' and 'invoker' refer to the same object and are synonyms.

1.6.1.8.7 Invocation

The invocation of an operation is the making of a request by an object (the invoker) to another object (the performer) to carry out the operation.

1.6.1.8.8 Master Channel

The sequence of all telemetry frames with the same Transfer Frame Version Number (TFVN) and the same SCID on the same physical channel constitutes a master channel.

NOTE – Depending on the TFVN, the definition of SCID is as given in either reference [3] or reference [5].

1.6.1.8.9 Operational Control Field

The Operational Control Field (OCF) of a telemetry frame is the frame OCF of either a TM Transfer Frame (reference [3]) or an AOS Transfer Frame (reference [5]).

1.6.1.8.10 Parameter

A parameter of an operation is data that may accompany the operation's invocation or return.

NOTE – The term parameter is also used to refer to mission-dependent configuration information used in the production or provision of the service.

1.6.1.8.11 Performance

The performance of an operation is the carrying out of the operation by an object (the performer).

1.6.1.8.12 Port Identifier

A port identifier identifies a source or a destination in a communications system.

NOTE – See 2.6.4.5 for more information.

1.6.1.8.13 Responder

The responder is the object that receives a request to bind and completes the binding (if possible) with the initiator in order for a service association to exist between the two objects.

NOTE – In other words, the responder is always the performer of the binding. Therefore, in the context of binding, the terms 'responder' and 'performer' refer to the same object and are synonyms.

1.6.1.8.14 Return

The return of an operation is a report, from the performer to the invoker, of the outcome of the performance of the operation.

1.6.1.8.15 Service Instance Provision Period

A service instance provision period is the time during which a service instance (i.e., the capability to transfer one or more SLE data channels of a given type) is scheduled to be provided.

NOTE – Reaching of the beginning of this period constitutes the event 'start of service instance provision period' (see 4.2.2).

Because the operations of the ROCF service are relatively simple, once an association is in place between the service user and the service provider, the technology-specific elements involved in the exchange of SLE-PDUs are generally minor. However, the way an association is established (i.e., the binding) tends to vary significantly depending on the communications technology in use. Nonetheless, the ROCF-BIND and ROCF-UNBIND operations as specified in this document are intended to be 'technology neutral'. This neutrality is achieved as described in the following paragraphs.

For purposes of the communications mapping, the endpoints of an SLE association are identified by port identifiers, namely, an 'initiator port identifier' and a 'responder port identifier'. The port identifiers represent all the technology-specific addressing information needed to establish communications between the user and provider and to route SLE-PDUs between them. The initiator port identifier identifies the endpoint that will invoke the ROCF-BIND operation (initiator). The responder port identifier identifies the endpoint that will perform the ROCF-BIND operation (responder). Generally speaking, the information represented by a port identifier consists of:

a) information needed in order to route data between two real systems over a communications channel or network; and

b) information needed in order to route data within a real system to a particular application entity.

For example, the information represented by a port identifier might be the combination of an Internet Protocol (IP) network address and a Transmission Control Protocol (TCP) port number or the combination of an OSI network address and an associated set of Service Access Points (SAPs).

The exact relationship between SLE port identifiers and communications ports provided by the underlying communications service must be specified by the mapping of the ROCF service to the underlying communications service. If the underlying communications service is connection-oriented, then the mapping may specify a one-to-one relationship between SLE associations and communications connections; however, that is not required. For example, two SLE associations involving the same pair of SLE endpoints may share a single connection. In that case, it is the responsibility of the mapping of the ROCF service to the underlying communications service to specify how the SLE-PDUs of one association are distinguished from the SLE-PDUs of the other association.

One possible mapping of the SLE transfer service to the TCP/IP communications service is specified in [E7]. As part of this mapping, also issues such as sizing of TCP buffers in accordance with the bandwidth-delay product of the communication link and ways to manage relative priority of transfer services concurrently using the same connectivity are to be addressed.

In order for an SLE association to be established, SLE Complex Management and SLE Utilization Management must agree beforehand on the responder port identifier for the association. The responder needs the information represented by the responder port

3.1.5 AUTHENTICATION

NOTE – Requirements for security depend on the application and the ~~SLE system~~ environment of the SLE Complexes and the MDOS (e.g., whether closed or public networks are used or if access is only from physically restricted areas). In many environments, security may be provided by the communications service, transparently to the SLE application. This Recommended Standard does not preclude the use of security features that are provided by the communications service or the local environment, nor does it assume the availability of such features.

3.1.5.1 The ROCF service shall provide the following options with respect to the level of authentication of invocations and returns of operations:

a) 'all': all ROCF invocations and returns, except the invocation of ROCF-PEER-ABORT, shall be authenticated;

b) 'bind': only the ROCF-BIND invocation and return shall be authenticated;

c) 'none': no ROCF invocations or returns shall be authenticated.

3.1.5.2 SLE Complex Management and SLE Utilization Management shall agree on the level of authentication to be required for an association between a service user and a service provider and shall configure both entities accordingly.

3.1.5.3 SLE Complex Management and SLE Utilization Management shall agree on the algorithm used to generate and check credentials parameters and shall make this algorithm known to the service user and service provider together with associated parameters such as passwords or keys as necessary for the selected algorithm.

NOTES

1 The specification of the algorithms themselves is outside the scope of this Recommended Standard.

2 The `initiator-identifier` and `responder-identifier` parameters of the ROCF-BIND operation identify the user and provider and therefore the applicable authentication level and algorithm necessary to generate and check credentials.

3.1.5.4 For operations for which authentication is required by the terms of the agreement between SLE Complex Management and SLE Utilization Management:

a) invocations shall include an `invoker-credentials` parameter to permit the performer to authenticate the invocation;

b) returns shall include a `performer-credentials` parameter to permit the invoker to authenticate the return.

3.1.6.8 Compliance with this Recommended Standard does not require the performer to process invocations concurrently; however, the performer must accept invocations from a non-blocking invoker and buffer and serialize them by local means not visible externally.

3.1.7 TIME

3.1.7.1 The time reference for all parameters containing a time value shall be based on Coordinated Universal Time (UTC).

NOTE – The type of all time parameters is specified in annex A.

3.1.7.2 The `earth-receive-time` parameter (see 3.6.2.3) shall be expressed using the CCSDS Day Segmented (CDS) time code (reference [7]) with ~~a resolution of one microsecond,~~ an epoch of 1958-01-01~~,~~ and a 16-bit day segment. Depending on the ROCF service provider capabilities and/or the supported mission requirements, the time tag may have either a resolution of microseconds or a resolution of picoseconds.

3.1.7.3 The `earth-receive-time` parameter shall have a precision of one millisecond or better.

3.1.7.4 The `earth-receive-time` parameter shall be accurate to within one millisecond or better.

3.1.8 SETTING OF PARAMETERS

3.1.8.1 An ROCF provider shall permit setting of the service configuration parameters as specified in table 3-1.

3.1.8.2 The range or set of values a parameter may assume is constrained by specification of its data type (see annex A).

3.1.8.3 Service management may further constrain the allowed values for a given service instance.

Table 3-1: Setting of ROCF Service Configuration Parameters

Parameter	Service Management	ROCF-START Operation	ROCF-SCHEDULE-STATUS-REPORT Operation
delivery-mode	X		
latency-limit	X		
maximum-delivery-rate	X		
maximum-reporting-cycle	X		
minimum-reporting-cycle	X		
permitted-global-VCID-set	X		
permitted-control-word-type-set	X		
permitted-tc-vcid-set	X		
permitted-update-mode-set	X		
reporting-cycle			X
requested-control-word-type		X	
requested-global-VCID		X	
requested-tc-vcid		X	
requested-update-mode		X	
return-timeout-period	X		
service-instance-provision-period	X		
service-version-number	X		
transfer-buffer-size	X		

NOTES

1 The user can ascertain the current value of the parameters presented in table 3-11 by means of the ROCF-GET-PARAMETER operation.

2 This Recommended Standard also refers to parameters that are set by service management, but are not listed in table 3-1. These parameters cannot be ascertained by means of the ROCF-GET-PARAMETER operation.

3.2.2.7.2 For ROCF service, the value of `service-type` shall be ‘Rtn Ch Ocf’.[1]

3.2.2.8 `version-number`

3.2.2.8.1 The **`version-number`** parameter shall identify the version number of the ROCF service specification that is to govern this association if ROCF-BIND succeeds.

3.2.2.8.2 `version-number` is conditionally present in the return based on the `result` parameter:

a) if the value of `result` is ‘positive result’, `version-number` shall be present in the return;

b) if the value of `result` is ‘negative result’, `version-number` shall not be present in the return.

3.2.2.8.3 If the value of the `result` parameter is ‘positive result’, the responder shall either:

a) accept the version proposed by the initiator by putting the same version number into the return; or,

b) if the responder supports version negotiation, propose a lower (earlier) version number by putting the lower number into the return.

3.2.2.8.4 If the responder implementation does not support the requested version and does not support a lower version (or does not support version negotiation), the responder shall reject the bind with the `diagnostic` parameter set to ‘version not supported’.

3.2.2.8.5 If the responder proposes a lower version and the initiator implementation does not support version negotiation or does not support the version proposed by the responder, the initiator shall unbind the association.

3.2.2.8.6 The value of the `version-number` parameter for the ROCF service defined by this issue of this Recommended Standard shall be ’~~1~~2’.

NOTE – The version negotiation process as outlined above is feasible only as long as future versions of the ROCF service do not modify the specification of the ROCF-BIND operation.

[1] For the ROCF-BIND operation, the `service-type` parameter is redundant, because the only valid value of `service-type` is ‘Rtn Ch Ocf’. However, it is anticipated that future work by CCSDS may result in ROCF-BIND being superseded by a generic SLE-BIND operation that is invoked with any one of several SLE service types. The ROCF-BIND `service-type` parameter is provided in an attempt to facilitate such a change.

Table 3-4: ROCF-START Parameters

Parameter	Invocation	Return
invoker-credentials	M	
performer-credentials		M
invoke-ID	M	M
start-time	M	
stop-time	M	
requested-global-VCID	M	
control-word-type	M	
tc-vcid	C	
update-mode	M	
result		M
diagnostic		C

3.4.2.2 `invoker-credentials`

The **`invoker-credentials`** parameter shall provide information that enables the performer to authenticate the ROCF-START invocation (see 3.1.5).

3.4.2.3 `performer-credentials`

The **`performer-credentials`** parameter shall provide information that enables the invoker to authenticate the return from the performance of ROCF-START (see 3.1.5).

3.4.2.4 `invoke-ID`

The ROCF service provider shall return unchanged the user-supplied value of the `invoke-ID` parameter (see 3.1.6).

3.4.2.5 `start-time`

3.4.2.5.1 The value of the **`start-time`** parameter shall be ‘null’, or it shall be a time value that indicates that only OCFs with an ERT equal to or later than `start-time` shall be delivered.

3.4.2.5.2 For the online delivery mode, only OCFs extracted from frames acquired during the space link session associated with this service instance shall be delivered, regardless of the value of `start-time`.

b) for the online delivery mode, `stop-time`, if not 'null', must be earlier than or equal to the end time of the service instance provision period for this service instance;

c) for the offline delivery mode, `stop-time` plus the offline processing latency must be earlier than the current time.

NOTES

1 Offline processing latency is the length of time after a frame is acquired from the space link before the frame or any fields contained in the frame is available for retrieval using the offline delivery mode. The actual value of offline processing latency is negotiated between SLE Complex Management and SLE Utilization Management.

2 Offline delivery is only available for frames that already have been acquired when the ROCF-START operation is invoked.

3.4.2.7 `requested-global-VCID`

3.4.2.7.1 The `requested-global-VCID` parameter shall identify the master channel or virtual channel that is to be used as source for the OCFs to be delivered to the user and shall consist of the TFVN, the SCID, and the VCID.

NOTES

1 The definitions of SCID and VCID depend on the TFVN. If the TFVN indicates that the virtual channel consists of TM Transfer Frames, then the definitions of SCID and VCID are as per reference [3]. If the TFVN indicates that the virtual channel consists of AOS Transfer Frames, then the definitions of SCID and VCID are as per reference [5].

2 The physical channel is not specified directly through the ROCF service. Rather, the selection of physical channel is determined through the service package, which specifies the RAF service instance that is consumed by the RFP-FG that is producing the ROCF service.

3 Depending on the configuration, for a given service instance, the selection of only one master channel or only one VC from a set of VCs (where the set may have a single member) or a single master channel plus a set of VCs is permitted. In case the permitted GVCID list contains a master channel but no virtual channels from that master channel, the service user is not permitted to request a virtual channel from this master channel.

3.4.2.7.2 The TFVN shall be a valid transfer frame version number defined by CCSDS.

NOTE – At the time of issuance of this Recommended Standard, the only valid TFVNs were '00' (version 1) and '01' (version 2) (see references [3] and [5]).

3.4.2.10 `update-mode`

3.4.2.10.1 The **`update-mode`** parameter shall specify if all or only a subset of the OCFs as extracted from the selected telemetry channel and containing the selected control word type and referring, if applicable, to the selected telecommand VC (see 3.4.2.8 and 3.4.2.9) shall be delivered to the user.

3.4.2.10.2 The update-mode parameter shall contain one of the following values:

a) 'continuous'—the OCF service provider shall insert into the transfer buffer an RocfTransferDataInvocation or the equivalent for each OCF that fulfills the delivery criteria specified by the parameters `start-time`, `stop-time`, `requested-global-VCID`, `control-word-type`, and `tc-vcid`;

b) 'change-based'—the OCF service provider shall insert into the transfer buffer an RocfTransferDataInvocation operation only if the OCF fulfills the delivery criteria specified by the parameters `start-time`, `stop-time`, `requested-global-VCID`, `control-word-type`, and `tc-vcid` and the content of the OCF is different than the one of the OCF with the same `tc-vcid` value previously inserted into the transfer buffer or if no such OCF had been delivered to the user since the most recent ROCF-START invocation.

3.4.2.11 `result`

The **`result`** parameter shall specify the result of the ROCF-START operation and shall contain one of the following values:

a) 'positive result'—the ROCF-START operation has been performed by the provider, and the provider shall henceforth invoke ROCF-TRANSFER-DATA operations as needed to transfer to the user all available OCFs that meet the specified delivery criteria;

b) 'negative result'—the ROCF-START operation has not been performed by the provider, and the provider shall not invoke any ROCF-TRANSFER-DATA operations even if OCFs are available.

3.4.2.12 `diagnostic`

3.4.2.12.1 If `result` is 'negative result', the `diagnostic` parameter shall be present in the return, and its value shall be one of the following:

a) 'duplicate Invoke-ID'—the value of the `invoke-ID` parameter is the same as the `invoke-ID` of a previous, outstanding operation;

b) 'out of service'—the provider has been taken out of service for an indefinite period by management action;

c) ‘unable to comply’—the provider is unable to transfer data at this time because of a fault affecting the provider;

d) ‘invalid start time’—the value of the `start-time` provided in the invocation is not valid;

e) ‘invalid stop time’—the value of the `stop-time` provided in the invocation is not valid;

f) ‘missing time value’—for the offline delivery mode, the value of `start-time` and/or `stop-time` was ‘null’;

g) ‘invalid global-VCID’—the value specified for the `requested-global-VCID` parameter is not valid, i.e., the value contained in the ROCF-START invocation is not in the set permitted by service management;

h) ‘invalid control word type’—the value specified for the `control-word-type` parameter is not valid;

i) ‘invalid tc-vcid’—the value specified for the `tc-vcid` parameter is not valid;

j) ‘invalid update-mode’—the value specified for the `update-mode` parameter is not valid, i.e., the update mode selected in the ROCF-START invocation is not permitted by service management;

k) ‘other reason’—the reason for the negative result will have to be found by other means.

3.4.2.12.2 If `result` is ‘positive result’, the `diagnostic` parameter shall not be present in the return.

3.4.3 EFFECTS

3.4.3.1 If `result` is ‘positive result’, the ROCF-START operation shall have the following effects:

a) the provider shall transition to state 3 (‘active’);

b) in the ‘active’ state, the provider shall transfer OCFs to the user whenever they are available and satisfy the delivery criteria.

3.4.3.2 If `result` is ‘negative result’, the ROCF-START operation shall have the following effects:

a) the provider shall remain in state 2 (‘ready’) and shall not deliver OCFs even if they are available;

b) if the diagnostic is ‘unable to comply’:

3.6 ROCF-TRANSFER-DATA

3.6.1 PURPOSE

3.6.1.1 The provider shall invoke the ROCF-TRANSFER-DATA operation to deliver an OCF to the user.

3.6.1.2 The ROCF-TRANSFER-DATA operation shall be an unconfirmed operation.

NOTE – Although ROCF-TRANSFER-DATA is an unconfirmed operation, it is assumed that the communications service provides certain guarantees, as described in 1.3.1.

3.6.1.3 ROCF-TRANSFER-DATA is valid only in state 3 (‘active’) and shall be invoked only by the provider.

3.6.2 INVOCATION~~, RETURN,~~ AND PARAMETERS

3.6.2.1 General

The parameters of the ROCF-TRANSFER-DATA operation shall be present in the invocation as specified in table 3-6.

Table 3-6: ROCF-TRANSFER-DATA Parameters

Parameters	Invocation
`invoker-credentials`	M
`earth-receive-time`	M
`antenna-ID`	M
`data-link-continuity`	M
`private-annotation`	M
`data`	M

3.6.2.2 `invoker-credentials`

The **`invoker-credentials`** parameter shall provide information that enables the user to authenticate the ROCF-TRANSFER-DATA invocation (see 3.1.5).

3.6.2.3 `earth-receive-time`

The **`earth-receive-time`** parameter shall contain the UTC time at which the signal event corresponding to the leading edge of the first symbol which has been influenced by the last bit of the attached sync marker that immediately preceded this telemetry frame was presented at the phase center of the antenna used to acquire the frame.

NOTE – In case of punctured coding, the number of symbols influenced by each information bit is variable, depending on the puncture pattern. To minimize the resulting jitter of the earth-receive-time annotation with respect to the beginning of the frame, the end of the attached sync marker is used as the reference event.

3.6.2.4 `antenna-ID`

3.6.2.4.1 The **`antenna-ID`** parameter shall indicate which antenna of the SLE Complex was used to acquire the frame containing the OCF.

NOTE – `antenna-ID` is provided specifically to identify the physical location used as the reference point for the `earth-receive-time` parameter.

3.6.2.4.2 SLE Complex Management and SLE Utilization Management shall mutually agree upon the allowable values for `antenna-ID` and their interpretation.

NOTE – It is assumed that the value of the `antenna-ID` parameter is a reference to the actual location information, which is provided outside the scope of this service.

3.6.2.5 `data-link-continuity`

3.6.2.5.1 The **`data-link-continuity`** parameter shall indicate whether the frame from which the OCF was extracted was the direct successor of the previous frame on the master or virtual channel selected by means the ROCF-START operation.

NOTE – If any of the delivery criteria parameters (e.g., `tc-vcid`) in the ROCF-START invocation are set such that only a subset of the OCFs extracted from the selected channel are delivered to the user, then the `data-link-continuity` parameter will show a discontinuity of the channel only if the frame from which the OCF was extracted was the first after a discontinuity on the channel.

3.6.2.5.2 The `data-link-continuity` parameter shall contain an integer value:

a) a value of '–1' shall indicate that the OCF is extracted from the first frame after the start of production or the selected channel is a master channel carrying AOS Transfer Frames and therefore no information regarding a discontinuity on the channel can be provided;

NOTE – AOS Transfer Frames do not contain a master channel frame counter.

b) a value of '~~(([MCFC$_n$ – MCFC$_{n-1}$] modulo 255) – 1)~~([MCFC$_n$ – MCFC$_{n-1}$ – 1] modulo 256)' if the selected channel is a master channel carrying transfer frames; MCFC$_n$ is the master channel frame count of the frame from which the OCF was extracted and MCFC$_{n-1}$ is the master channel frame count of the previous frame delivered by the production process for the given master channel;

c) a value of '~~(([VCFC$_n$ – VCFC$_{n-1}$] modulo 255) – 1)~~([VCFC$_n$ – VCFC$_{n-1}$ – 1] modulo 256)' if the selected channel is a virtual channel carrying TM Transfer Frames; VCFC$_n$ is the virtual channel frame count of the frame from which the OCF was extracted and VCFC$_{n-1}$ is the virtual channel frame count of the previous frame delivered by the production process for the given virtual channel.

d) a value of '~~(([VCFC$_n$ – VCFC$_{n-1}$] modulo 16777215) – 1)~~([VCFC$_n$ – VCFC$_{n-1}$ – 1] modulo 16777216)' if the selected channel is a virtual channel carrying AOS Transfer Frames; VCFC$_n$ is the virtual channel frame count of the frame from which the OCF was extracted and VCFC$_{n-1}$ is the virtual channel frame count of the previous frame delivered by the production process for the given virtual channel.

NOTE – The number of missing TM Transfer Frames reported is correct as long as the gap is less than 256 frames. For longer gaps it will normally be possible to resolve the ambiguity resulting from the modulo ~~255~~256 count based on the ERT of the frames and the nominal frame rate on the given master channel or virtual channel. For AOS Transfer Frames, the likelihood of an incorrectly reported gap size is much lower.

3.6.2.6 `private-annotation`

The **`private-annotation`** parameter shall be used to convey additional information that may be associated with a frame:

a) it may be set to 'null' to indicate that there is no private annotation;

b) if not 'null', there must be a prior arrangement between SLE Complex Management and SLE Utilization Management regarding the contents and interpretation of this parameter.

3.6.2.7 `data`

The value of the **`data`** parameter shall be the OCF extracted from the telemetry frame acquired by the provider from the RAF channel for delivery to the user.

3.6.3 EFFECTS

The ROCF-TRANSFER-DATA operation shall have the following effects:

3.7 ROCF-SYNC-NOTIFY

3.7.1 PURPOSE

3.7.1.1 The ROCF service provider shall invoke the ROCF-SYNC-NOTIFY operation to notify the user of the occurrence of an event affecting the production of the ROCF service.

NOTE – Notification of events may be of value to the user in understanding specific provider behavior, such as an interruption in OCF delivery.

3.7.1.2 The ROCF-SYNC-NOTIFY operation shall be an unconfirmed operation.

3.7.1.3 The order in which the ROCF-SYNC-NOTIFY and ROCF-TRANSFER-DATA operations are invoked shall reflect the actual chronology of events.

NOTE – For example, if an ROCF-SYNC-NOTIFY operation is invoked after one ROCF-TRANSFER-DATA operation but before another, then the event indicated by the notification occurred after the ERT of the frame associated with the preceding ROCF-TRANSFER-DATA but before the ERT of the frame associated with the following ROCF-TRANSFER-DATA.

3.7.1.4 ROCF-SYNC-NOTIFY is valid only in state 3 (‘active’) and shall be invoked only by the provider.

3.7.2 INVOCATION~~, RETURN,~~ AND PARAMETERS

3.7.2.1 General

The parameters of the ROCF-SYNC-NOTIFY operation shall be present in the invocation as specified in table 3-7.

Table 3-7: ROCF-SYNC-NOTIFY Parameters

Parameter	Invocation
`invoker-credentials`	M
`notification-type`	M
`notification-value`	C

3.7.2.2 `invoker-credentials`

The **`invoker-credentials`** parameter shall provide information that enables the user to authenticate the ROCF-SYNC-NOTIFY invocation (see 3.1.5).

3.9 ROCF-STATUS-REPORT

3.9.1 PURPOSE

3.9.1.1 The provider shall invoke the ROCF-STATUS-REPORT operation to send a status report to the user.

3.9.1.2 ROCF-STATUS-REPORT shall be an unconfirmed operation.

3.9.1.3 Status reports shall be sent (or not sent) in accordance with user requests conveyed by means of the ROCF-SCHEDULE-STATUS-REPORT operation (see 3.8).

3.9.1.4 The ROCF-STATUS-REPORT operation is valid only in states 2 (‘ready’) and 3 (‘active’) and shall be invoked only by the provider.

3.9.2 INVOCATION~~, RETURN,~~ AND PARAMETERS

3.9.2.1 General

The parameters of the ROCF-STATUS-REPORT operation shall be present in the invocation as specified in table 3-9.

Table 3-9: ROCF-STATUS-REPORT Parameters

Parameters	Invocation
`invoker-credentials`	M
`number-of-frames-processed`	M
`number-of-ocfs-delivered`	M
`frame-sync-lock-status`	M
`symbol-sync-lock-status`	M
`subcarrier-lock-status`	M
`carrier-lock-status`	M
`production-status`	M

3.9.2.2 `invoker-credentials`

The **`invoker-credentials`** parameter shall provide information that enables the performer to authenticate the ROCF-STATUS-REPORT invocation (see 3.1.5).

3.9.2.3 number-of-frames-processed

The **number-of-frames-processed** parameter shall specify the total number of telemetry frames that have been processed for extracting OCFs, i.e., the number of frames with the ~~selected~~ requested-global-VCID value, since the start of the service instance provision period.

NOTE – This parameter is equivalent to the number of frames that an RCF service instance with the same ~~selected~~ requested-global-VCID value would deliver to the user while the service instance is in the active state.

3.9.2.4 number-of-ocfs-delivered

The **number-of-ocfs-delivered** parameter shall specify the total number of OCFs delivered to the user since the start of the service instance provision period.

3.9.2.5 frame-sync-lock-status

The **frame-sync-lock-status** parameter shall specify the current lock status of the frame synchronization process, the value of which shall be ‘in-lock’, ‘out-of-lock’, or ‘unknown’.

3.9.2.6 symbol-sync-lock-status

The **symbol-sync-lock-status** parameter shall specify the current lock status of the symbol (or bit) synchronization process, the value of which shall be ‘in-lock’, ‘out-of-lock’, or ‘unknown’.

3.9.2.7 subcarrier-lock-status

The **subcarrier-lock-status** parameter shall specify the current lock status of the subcarrier demodulation process, the value of which shall be ‘in-lock’, ‘out-of-lock’, ‘not in use’, or ‘unknown’.

3.9.2.8 carrier-lock-status

The **carrier-lock-status** parameter shall specify the current lock status of the carrier demodulation process, the value of which shall be ‘in-lock’, ‘out-of-lock’, or ‘unknown’.

Parameter	Description
requested-update-mode	The update-mode requested by the most recent ROCF-START operation (see 3.4.2.10) if the service instance is in the 'active' state; 'undefined' otherwise.
return-timeout-period	The maximum time period (in seconds) permitted from when a confirmed ROCF operation is invoked until the return is received by the invoker (see 4.1.3).
transfer-buffer-size	The size of the transfer buffer ~~(see 3.1.9)~~: the value of this parameter shall indicate the number of ROCF-TRANSFER-DATA and ROCF-SYNC-NOTIFY invocations that can be stored in the transfer buffer. The precise specification of the transfer buffer size may be found in 3.1.9.

3.10.2.8 `diagnostic`

3.10.2.8.1 If `result` is 'negative result', the **`diagnostic`** parameter shall be present in the return, and its value shall be one of the following:

a) 'duplicate Invoke-ID'—the value of the `invoke-ID` parameter is the same as the `invoke-ID` of a previous, outstanding operation;

b) 'unknown parameter'—the value of `rocf-parameter` does not identify an ROCF parameter that is recognized by the service provider;

c) 'other reason'—the reason for the negative result will have to be found by other means.

3.10.2.8.2 If `result` is 'positive result', the `diagnostic` parameter shall not be present in the return.

3.10.3 EFFECTS

3.10.3.1 If `result` is 'positive result', the value of the ROCF parameter specified in the invocation shall be provided to the user in the return.

3.10.3.2 If `result` is 'negative result', no ROCF parameter value shall be returned to the user.

3.10.3.3 The state of the provider shall not change.

3.11 ROCF-PEER-ABORT

3.11.1 PURPOSE

3.11.1.1 The user or provider shall invoke the ROCF-PEER-ABORT operations to notify the peer system that the local application detected an error that requires that the association between them be terminated abnormally.

3.11.1.2 ROCF-PEER-ABORT shall be an unconfirmed operation.

3.11.1.3 ROCF-PEER-ABORT is valid only in states 2 (‘ready’) and 3 (‘active’) and may be invoked by either the user or the provider.

3.11.2 INVOCATION~~, RETURN,~~ AND PARAMETERS

3.11.2.1 General

The parameters of the ROCF-PEER-ABORT operation shall be present in the invocation as specified in table 3-12.

Table 3-12: ROCF-PEER-ABORT Parameters

Parameters	Invocation
`diagnostic`	M

3.11.2.2 `diagnostic`

The **`diagnostic`** parameter shall specify why the ROCF-PEER-ABORT is being invoked, and its value shall be one of the following:

a) ‘access denied’—a responder with an identity as presented in the `responder-identifier` parameter of the ROCF-BIND return is not known to the initiator (e.g., the value of the `responder-identifier` parameter does not match the authorized responder for any service instance known to the initiator);

b) ‘unexpected responder ID’—the value of the `responder-identifier` parameter in the ROCF-BIND return does not match the identity of the authorized responder for this service instance as specified by service management;

c) ‘operational requirement’—the local system had to terminate the association to accommodate some other operational need;

d) ‘protocol error’—the local application detected an error in the sequencing of ROCF service operations;

4 ROCF PROTOCOL

4.1 GENERIC PROTOCOL CHARACTERISTICS

NOTE – This section specifies the handling of invalid SLE-PDUs and other failures affecting the protocol.

4.1.1 UNEXPECTED PROTOCOL DATA UNIT

If the peer application invokes an operation not allowed in the current state of the performer, the performer shall abort the association by invoking the ROCF-PEER-ABORT operation with the `diagnostic` parameter set to 'protocol error'.

4.1.2 INVALID PROTOCOL DATA UNIT

If the application receives an invocation or return that contains an unrecognized operation type, contains a parameter of the wrong type, or is otherwise not decodable, the application shall abort the association by invoking the ROCF-PEER-ABORT operation with the `diagnostic` parameter set to 'encoding error'.

4.1.3 MISSING RETURN

For confirmed operations, if the invoker does not receive the return from the performer within a timeout period specified by service management, the invoker shall abort the association by invoking the ROCF-PEER-ABORT operation with the `diagnostic` parameter set to 'return timeout'.

NOTES

1 The timeout period shall be chosen taking into account performance of user and provider applications as well as the delays introduced by the underlying communications service.

2 In order to provide responsive service and short timeout periods, the generation of the return from an operation must not depend on any human interaction.

3 After invoking the ROCF-UNBIND operation, the initiator must not invoke any further operations with the exception of the case addressed in 3.3.1.4 nor send any returns. The responder is not required to send any pending returns after having received the ROCF-UNBIND invocation. Therefore, following an ROCF-UNBIND invocation, the 'missing return' event may occur.

Table 4-2: Event Description References

Event	Reference
'data available'	3.1.9.1.2, 3.1.9.2.2, 3.1.9.3.2
'end of data'	3.7.2.3
'end of service instance provision period'	3.11.2.2
'invalid protocol data unit'	4.1.2
'loss of frame synchronization'	3.7.2.3
'not authenticated SLE-PDU'	4.1.7
'production status change'	3.7.2.3
'release timer expired'	3.1.9.1.4, 3.1.9.2.6
'reporting-cycle timer expired'	3.8.2.6
'return SLE-PDU with unsolicited Invoke-ID'	4.1.4
'return <n> timer expired'	4.1.3
'start of service instance provision period'	1.6.1.8.15

Table 4-3: Predicate Descriptions

Predicate	Evaluates to TRUE if
"buffer empty"	There are no ROCF SLE-PDUs in the transfer buffer
"buffer full"	The transfer buffer cannot accommodate the currently available annotated OCF or synchronous notification
"compatible"	The version number contained in (+rocfBindReturn) is supported by the provider
"complete online"	Delivery mode is complete online
~~"congested"~~	~~The underlying communications service cannot accept the contents of the transfer buffer because of congestion~~
"done"	The unbind-reason parameter value in the provider-initiated BIND invocation was 'end'
"end"	All checks on the UNBIND invocation are passed and the unbind-reason parameter value is 'end'
"immediately"	All parameter checks on the ROCF-SCHEDULE-STATUS-REPORT are passed and the `report-request-type` value is 'immediately'
"offline"	Delivery mode is offline
"online"	Delivery mode is timely online or complete online
"periodically"	All parameter checks on the ROCF-SCHEDULE-STATUS-REPORT are passed and the `report-request-type` value is 'periodically'
"positive result"	All checks on the invocation are passed

Predicate	Evaluates to TRUE if
"provider initiated"	The ROCF-BIND operation is specified to be initiated by the provider for this service instance
“provision period”	Current time is inside the service instance provision period
“retry permitted”	The diagnostic value contained in the (-rocfBindReturn) is ‘unable to comply’ or ‘other’, and the service instance provision period is still active
“timely online”	Delivery mode is timely online

Table 4-4: Boolean Flags

Flag Name	Initial Value
“bind pending”	FALSE
“congested”	FALSE
“unbind pending”	FALSE

Table 4-5: Compound Action Definitions

Name	Actions Performed
{clean up}	stop release timer stop all return timers stop reporting-cycle timer reinitialize transfer buffer reset parameter values to those specified in service package
{immediate report}	(rocfStatusReportInvocation) stop reporting-cycle timer
{insert annotated OCF}	annotate the available OCF with the parameters of the ROCF-TRANSFER-DATA operation insert the annotated OCF into the transfer buffer
{invoke bind}	(rocfBindInvocation) set “bind pending” to TRUE start return <n> timer
{invoke unbind}	(rocfUnbindInvocation) stop reporting-cycle timer set “unbind pending” to TRUE start return <n> timer
{pass buffer contents}	stop release timer submit contents of transfer buffer to underlying communications service IF successful THEN set “congested” to FALSE ELSE set “congested” to TRUE reinitialize transfer buffer using the nominal size

Name	Actions Performed
{peer abort 'xxxx'}	stop release timer stop all return timers stop reporting-cycle timer reinitialize transfer buffer (rocfPeerAbortInvocation) with diagnostic set to 'xxxx'
{periodic report}	(rocfStatusReportInvocation) set reporting-cycle timer to the `reporting-cycle` value in the most recent SCHEDULE-STATUS-REPORT invocation start reporting-cycle timer
{provider unbind}	set "unbind pending" to FALSE stop all return timers
{return timeout}	(rocfPeerAbortInvocation) with diagnostic 'return timeout' set "bind pending" to FALSE set "unbind pending" to FALSE
{start release timer}	set release timer to latency limit start release timer
{sync notify 'xxxx'}	create an ROCF synchronous notification with ~~diagnostic~~`notification-type` set to 'xxxx' insert the notification into the transfer buffer
{transmit buffer}	stop release timer submit the contents of transfer buffer to underlying communications service until accepted by that service reinitialize transfer buffer
{user unbind}	stop reporting-cycle timer stop all return timers (rocfUnbindReturn)

```
ParameterName                          ::=   INTEGER
{  apidList                                  (2)
,  bitLockRequired                           (3)
,  blockingTimeoutPeriod                     (0)
,  blockingUsage                             (1)
,  bufferSize                                (4)
,  deliveryMode                              (6)
,  directiveInvocation                       (7)
,  directiveInvocationOnline                 (108)
,  expectedDirectiveIdentification           (8)
,  expectedEventInvocationIdentification     (9)
,  expectedSlduIdentification                (10)
,  fopSlidingWindow                          (11)
,  fopState                                  (12)
,  latencyLimit                              (15)
,  mapList                                   (16)
,  mapMuxControl                             (17)
,  mapMuxScheme                              (18)
,  maximumFrameLength                        (19)
,  maximumPacketLength                       (20)
,  maximumSlduLength                         (21)
,  modulationFrequency                       (22)
,  modulationIndex                           (23)
,  permittedControlWordTypeSet               (101)
,  permittedGvcidSet                         (24)
,  permittedTcVcidSet                        (102)
,  permittedTransmissionMode                 (107)
,  permittedUpdateModeSet                    (103)
,  plopInEffect                              (25)
,  reportingCycle                            (26)
,  requestedControlWordType                  (104)
,  requestedFrameQuality                     (27)
,  requestedGvcid                            (28)
,  requestedTcVcid                           (105)
,  requestedUpdateMode                       (106)
,  returnTimeoutPeriod                       (29)
,  rfAvailable                               (30)
,  rfAvailableRequired                       (31)
,  segmentHeader                             (32)
,  subcarrierToBitRateRatio                  (34)
,  timeoutType                               (35)
,  timerInitial                              (36)
,  transmissionLimit                         (37)
,  transmitterFrameSequenceNumber            (38)
,  vcMuxControl                              (39)
,  vcMuxScheme                               (40)
,  virtualChannel                            (41)
}

SlduStatusNotification  ::=   INTEGER
{  produceNotification           (0)
,  doNotProduceNotification      (1)
}

SpaceLinkDataUnit       ::=   OCTET STRING (SIZE (41 .. 65536))
```

```
Time                    ::=   CHOICE
{  ccsdsFormat       [0]   TimeCCSDS
,  picoFormat        [1]   TimeCCSDSpico
}

TimeCCSDS               ::=   OCTET STRING (SIZE(8))
-- P-field is implicit (not present, defaulted to 41 hex
-- T-field:
-- 2 octets: number of days since 1958/01/01 00:00:00
-- 4 octets: number of milliseconds of the day
-- 2 octets: number of microseconds of the millisecond
--        (set to 0 if not used)
-- This definition reflects exactly the format of the CCSDS defined
-- time tag as used in spacelink data units (see Time Code Formats.
-- Recommendation for Space Data Systems Standards, CCSDS 301.0-B-3.
-- Blue Book. Issue 3. Washington, D.C.: CCSDS, January 2002).

TimeCCSDSpico           ::=   OCTET STRING (SIZE(10))
-- P-field is implicit (not present, defaulted to 42 hex
-- T-field:
-- 2 octets: number of days since 1958/01/01 00:00:00
-- 4 octets: number of milliseconds of the day
-- 4 octets: number of picoseconds of the millisecond
--        (set to 0 if not used)
-- This definition reflects exactly the format of the CCSDS defined
-- time tag as used in spacelink data units (see Time Code Formats.
-- Recommendation for Space Data System Standards, CCSDS 301.0-B-3.
-- Blue Book.  Issue 3.  Washington, D.C.: CCSDS, January 2002).

END
```

```
-- ============================================================
-- The second part of the module definition contains the types
-- used by the ROCF-PDUs declared in the first part.
-- ============================================================

RocfGetParameterInvocation    ::= SEQUENCE
{  invokerCredentials            Credentials
,  invokeId                      InvokeId
,  rocfParameter                 RocfParameterName
}

RocfStartInvocation           ::= SEQUENCE
{  invokerCredentials            Credentials
,  invokeId                      InvokeId
,  startTime                     ConditionalTime
,  stopTime                      ConditionalTime
,  grequestedGvcId               GvcId
,  controlWordType               ControlWordType
,  updateMode                    UpdateMode
}

END
```

Term	Reference
service user (user)	reference [1]
SLE Complex	reference [1]
SLE Complex Management	reference [1]
SLE data channel	reference [1]
SLE Functional Group (SLE-FG)	reference [1]
SLE Protocol Data Unit (SLE-PDU)	reference [1]
SLE Service Data Unit (SLE-SDU)	reference [1]
SLE service package	reference [1]
~~SLE System~~	~~reference [1]~~
SLE transfer service instance	reference [1]
SLE transfer service production	reference [1]
SLE transfer service provision	reference [1]
SLE Utilization Management	reference [1]
spacecraft identifier	subsection 1.6.1.8.16
space link	reference [1]
space link data channel	reference [1]
Space Link Data Unit (SL-DU)	reference [1]
space link session	reference [1]
telemetry frame	subsection 1.6.1.8.17
timely (online delivery mode)	subsections 2.3, 3.1.9.1
TM Transfer Frame	reference [3]
transfer buffer	subsections 2.6.4.6.2, 3.1.9
Transfer Frame Version Number	subsection 1.6.1.8.18
unbound (state)	subsection 2.6.4.2
unconfirmed operation	subsection 1.6.1.8.18
user-initiated	subsections 2.3, 3.2.1
virtual channel	subsection 1.6.1.8.20
virtual channel identifier (VCID)	subsection 1.6.1.8.21
Virtual Channel Operational Control Field SLE data channel (VCOCF channel)	reference [1]

ANNEX E

INFORMATIVE REFERENCES

(INFORMATIVE)

[E1] *Procedures Manual for the Consultative Committee for Space Data Systems*. CCSDS A00.0-Y-9. Yellow Book. Issue 9. Washington, D.C.: CCSDS, November 2003.

[E2] *Cross Support Concept — Part 1: Space Link Extension Services*. Report Concerning Space Data System Standards, CCSDS 910.3-G-3. Green Book. Issue 3. Washington, D.C.: CCSDS, March 2006.

[E3] *Telemetry Channel Coding*. Recommendation for Space Data System Standards, CCSDS 101.0-B-6-S. Historical Recommendation. Issue 6-S. Washington, D.C.: CCSDS, (October 2002) August 2005.

[E4] *Packet Telemetry*. Recommendation for Space Data System Standards, CCSDS 102.0-B-5-S. Historical Recommendation. Issue 5-S. Washington, D.C.: CCSDS, (November 2000) August 2005.

[E5] *Telecommand Part 2—Data Routing Service*. Recommendation for Space Data System Standards, CCSDS 202.0-B-3-S. Historical Recommendation. Issue 3-S. Washington, D.C.: CCSDS, (June 2001) August 2005.

[E6] *Advanced Orbiting Systems, Networks and Data Links: Architectural Specification*. Recommendation for Space Data System Standards, CCSDS 701.0-B-3-S. Historical Recommendation. Issue 3-S. Washington, D.C.: CCSDS, (June 2001) August 2005.

[E7] *Space Link Extension—Internet Protocol for Transfer Services*. Recommendation for Space Data System Standards, CCSDS 913.1-B-1. Blue Book. Issue 1. Washington, D.C.: CCSDS, September 2008.